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Maine Agricultural Experiment Station

ORONO

BULLETIN No. 173.

DECEMBER, 1909.

CHERMES OF MAINE CONIFERS.

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BULLETIN No. 173.

CHERMES OF MAINE CONIFERS*

BY EDITH M. PATCH.

THE PINE LEAF CHERMES.

Chermes pinifoliae Fitch.

Chermes abieticolens Thos.

It is manifestly a pleasure to reinstate a species lost in a list of synonyms and an unusually interesting situation is found in the present study which justifies removing a species merged by error with two widely different Chermes† one on pine and one on spruce, and uniting these two forms in turn under the name of the form first described.

The species under consideration develops in a cone-like gall on the black spruce and migrates to the needles of the white pine to oviposit and was named, as commonly happens with aphids with two distinct host plants, separately in each situation.

The evidence concerning each will be taken in turn. Fitch's description of *Chermes pinifoliae*,‡ (though without figures or much structural detail) is excellent in that it selects several distinctly characteristic phases of this species and is sufficient to distinguish it from any of the other *Chermes* recorded in this paper.

Fitch's published account of the species is here given in full:

"267. Pine-Leaf Chermes, *Chermes Pinifoliae*, new species.

"Stationary upon the leaves, usually towards their ends, puncturing them and sucking their juices, a very small black fly 0.08** long to the tip of its abdomen, and 0.12 to the end of

* Papers from the Maine Agricultural Experiment Station: Entomology No. 39.

† *Chermes pinicorticis* and *Chermes abietis*.

‡ Trans. N. Y. Agric. Soc. 17: 741; id. Rept. Ins. N. Y. 4: 55, 1858.

** Fitch's measurements are given in decimals of inches.

its wings, which are dusky gray, its abdomen dusky red and slightly covered with fine cottony down.

"The females of these insects do not extrude their eggs. Clinging closely to the leaf with their heads towards its base, they die, their distended abdomens appearing like a little bag filled with eggs. The outer skin of the abdomen soon perishes and disappears, leaving the mass of eggs adhering to the side of the leaf, but completely covered over and protected by the closed wings of the dead fly. I have met with the dead females thus adhering to the leaves the first of July, and have noticed the same insects on the leaves in full life and vigor the middle of May.

"The rib vein of the fore wings runs straight to the outer margin forward of the tip, and gives off from its middle on the outer side a very oblique branch which runs to the outer margin, its tip producing a slight angular projection to the edge of the wing, and the whole space on the outer side of the rib vein beyond this branch is more opaque than the rest of the wing and of a smoky yellowish color. From its inner side the rib vein sends off three simple oblique veins, the last one of which ends in the extreme tip of the wing. The hind wings have an angular point on their outer side beyond the middle, and a longitudinal rib vein, which, forward of its middle sends off a branch almost transversely inward, its tip curved backward. The antennae are short, thread-like, and composed of four or five small joints. It will hence be seen that this insect is a true *Chermes*—the first species of this genus that has been discovered in this country."

The fact that a *Chermes* described by Fitch as 0.08 inches long to the end of the abdomen (0.12 inches long to the tip of the wings) and the accurate and characteristic account of the place and manner of ovipositing on the pine needles could have been considered the same as *Chermes pinicorticis** for the past 40 years, is sufficient proof that none of the observers who have worked with *pinicorticis* have been familiar with Fitch's other species, i. e., *pinifoliae*.

* 1869, Shimer. Trans. Am. Ent. Soc. II, 383.

1884, Osborn. Bull. A. E. S. Ia. No. 2, 97-105.

1898, Stormont, Rept. Ent. Ill. 20 iii-xxiii, pl. i-ii.

Thomas in his third report makes the following statement† concerning *abieticolens*.

"CHERMES (ABIETICOLENS?)

"Adeleges of the Spruce. Packard.

"A rather large species mentioned by Dr. Packard as 'found in abundance on the spruce in Maine, where it produces swellings at the ends of the twigs, resembling in size and form the cones of the same tree.' The specific name is applied provisionally and only for use in this report. This is certainly distinct from the European species *Chermes abietis* Linn., which is much smaller, of a bright reddish-brown color, with the wings tinged with green."

Packard‡ reports this species as follows:

"37. The Spruce Bud-louse, *Adelges abieticolens*, Thomas.

"Deforming the terminal shoots of the spruce, producing large swellings, which would be readily mistaken for the cones of the same tree.

"We take the following account and illustration from our Guide to the Study of Insects:

"The genus *Adelges* was proposed by Vallot for certain broad, flattened plant-lice which attack coniferous trees, often raising swellings on twigs like pine and spruce cones. The antennae are short, 5-jointed and slender; there are three straight veinlets arising from the main subcostal vein and directed outwards, and there are no honey tubes; otherwise these insects closely resemble the Aphides. A species closely related to the European *Adelges* (*Chermes*) *coccineus* of Ratzeburg, and the *A. strobilobius* of Kaltenbach, which have similar habits, we have found in abundance on the spruce in Maine, where it produces swellings at the ends of the twigs resembling in size and form the cones of the same tree. We would add that each leaf-bud is enlarged, having an *Adelges* under it. As those nearest the base mature first and leave their domicile, the deformed leaf-bud stands out from the axis of the shoot, thus giving the conelike appearance to the end of the shoot.'

"This has since been described by Prof. Cyrus Thomas in his Third Report on the Injurious Insects of Illinois, p. 156."

† Rept. Ent. Ill. 8: 156, 1879.

‡ Insects Injurious to Forest and Shade Trees.

That Packard himself was familiar with the galls of both *abieticolens* and the European *abietis* and considered them distinct is shown by his item which follows the foregoing one just quoted:

"38. The European Spruce Bud-louse, *Adelges abietis* Linn.

"We observed this species in considerable numbers on the Norway spruces on the grounds of the Peabody Academy of Science at Salem, in August, 1881. The deformation produced in the terminal buds and twigs were like those figured in Ratzeburg's *Die Waldverderbniss*, Bd. i, Pl. 28, figs. 1, 2."

Thomas states that he was certain that he was dealing with a distinct species, and one brief item is sufficient to prove him correct, for he uses one difference which is alone enough to separate these two species when he says that with the European species, *Chermes abietis* Linn. "the wings are tinged with green". While color distinctions are often an unsafe basis, it is steadfast one here, for *Chermes abietis* has uniformly and conspicuously green wings while the dark species developing in that Spruce gall ("found in abundance on the spruce in Maine") which when deserted "stands out from the axis of the shoot, thus giving the cone-like appearance to the end of the shoot" has the stigmal region reddish brown, or 'smoky yellowish,' and never at all greenish either when newly emerged from the gall or upon aging.

It seemed desirable in a circumstance so complicated to give, before presenting original data, the historical situation for the species under consideration, which develops in a cone-like gall on the black spruce (in which connection it was named *abieticolens* in 1879 by Thomas and subsequently merged by error with *abietis**), and migrates to the needles of the white pine (in which connection it had been previously named *pinifoliae* by Fitch, 1858, and merged by error with *pinicorticis*† in 1869 where it has remained for 40 years in oblivion).

* Fernald and Cooley, 34th Report Mass. Agric. College 1897, pp. 89-100.

† Shimer. Trans. Am. Ent. Soc. 2: 383.

CHERMES PINIFOLIAE IN MAINE.

On June 16, 1905, I first found winged *Chermes* in great abundance on the needles of white pine (*Pinus strobus*) at Orono. My notes for that date state that on some branches nearly every pine needle had a *Chermes* stationed near the tip with the head away from the tip. On some needles were three or four. Most of the specimens observed at this date were dead. A large cluster of eggs was found beneath the wings of each *Chermes*. Eggs brought in June 16 hatched June 26.

Immediate reference to Fitch's description gave such a striking agreement of my notes with his account of the egg laying habit of *Chermes pinifoliae* that I listed the collection under the name of that species. Mounts were made of the freshest specimens a few of which were still alive. These I took with considerable other material to Mr. Pergande the following winter and he kindly compared them with Fitch's type* of *Chermes pinifoliae* and stated that the type specimen was too imperfect to give a satisfactory basis of comparison but that in size and in such points as could be compared the two agreed and that he considered the specimens from Maine to be *pinifoliae*.

July 5, 1907, at Milo, Maine, I observed this species very abundant on the needles of white pine. The specimens were all dead at this date but they still adhered to the needles, on some of which there were as many as 14 or 16 in Indian file with their heads towards the base of the needle. This was in accordance with Fitch's observation "I have met with the dead females thus adhering to the leaves the first of July." Specimens of this collection were photographed as taken. See Fig. 127.

On June 14, 1909, a large number of black spruce twigs were brought to me with the statement that "almost every cone is infested under the scales and is abnormal in form." Some of these specimens are shown in Figs. 128 and 129. The infested growths at this stage were indeed so cone like that I took their cone-ship for granted until I read over Packard's discussion of *abieticolens* Thomas which he "found in abund-

* Fitch's aphid types were originally mounted on card points on pins. A few of these came finally to the U. S. collection where they were removed and are preserved as balsam mounts.

ance on the spruce in Maine, where it produces swellings at the ends of the twigs resembling in size and form the cones of the same tree." Dissection of the galls, of course, proved they were not abnormal *cones* but abnormal *shoots*.

The mistaken identity of the so-called "cones" seemed a good joke entomologically and as the collector of the galls is a plant morphologist perhaps not less so botanically.

Both the galls and the *Chermes* in them are distinct from *abietis* and there seems no ground for doubting that this species is *abieticolens*.

Some of the more advanced galls of *Chermes abieticolens* were opening on date of collection, June 14, and by June 21 fresh *Chermes pinifoliae* were on the needles of White Pine everywhere in the neighborhood of Orono. Others were sent in from other parts of the state a little later. Accompanying such specimens from Gilead vicinity on June 25 "millions of the flies on white pines" were reported.

As the disappearance of the emerging *abieticolens* from the spruce coincided exactly in time with the appearance of *pinifoliae* on the white pine and as there was no apparent difference in the *Chermes* in these two situations the conclusion was obvious enough and careful microscopic comparison was, of course, made. There was no difference between the two discoverable in any structure submitted to this sort of examination. The freshest of the specimens on the white pine had of course to be used for the comparison.

A check migration test was made June 22. A lot of galls from the black spruce were placed in a cage with fresh twigs of various conifers. On June 25, more than 200 individuals had settled on the white pine where they remained with their eggs. Although specimens were found crawling over some of the spruce twigs supplied them no individual settled and oviposited except on the white pine. This was more overwhelming preference than is usual with a cage test, for often in confinement a few stray specimens oviposit amiss, as it happens also to insects in the open. Perhaps if the test had been prolonged some of these would, but three days with the uniform result of 200 to 0 seemed sufficient.

In confinement, as in the open, these *Chermes* settled on the pine needles with the head toward the base of the needle. Out

of the thousands seen this season only very rarely was one found headed in the other direction. In confinement as in the open this species did not "oviposit" in the usual sense of the term, as the eggs were not expelled. As Fitch himself accurately recorded what I have observed three seasons (1905, 1907, 1909*) "the females of these insects do not extrude their eggs. Clinging closely to the leaf with their heads towards its base, they die, their distended abdomens appearing like a little bag filled with eggs. The outer skin of the abdomen soon perishes and disappears, leaving the mass of eggs adhering to the side of the leaf, but completely covered over and protected by the closed wings of the dead fly." Such an egg cluster comprises about 100 eggs.

The eggs of the *Chermes* which settled on the pine needles June 22-25, in the cage migration test recorded, were hatching July 3, in conspicuous numbers.

These young, the progeny of the migrants, settle at the tips of the new pine shoots where by the latter part of July their presence is rendered conspicuous on account of the white waxy secretion of the *Chermes*. This secretion gives a white woolly appearance to the infested portion similar to but much less dense than that of *pinicorticis* on the trunk of the white pine.

Where the infestation is heavy it causes a yellowish and sickly appearance of the new growth which is thus considerably stunted. As will be seen by Fig. 132 taken July 23, 1909, the new needles are not at this time full grown. The new needles on twig photographed were yellowish for a part of their length and the whole tip of the twig had an unhealthy appearance.

It will be seen from the date of the flight of this species from the spruce galls to the pine, about June 15-21, that the pine leaves on which they settle to oviposit are those of previous years growth, that is, the needles of 1909 have not started sufficiently for the *pinifoliae* of June 1909 to use.

This fact is in contrast with a second species, *Chermes floccus*, migrating from black spruce galls to pine needles late in July

*I am not able at present to state whether there may be any significance in this once in two years collection or not. I had not been paying any particular attention to *Chermes* and they may have been present in considerable numbers the other years also, and I had merely neither collected nor recorded them. The notes as they stand suggest a two year cycle but no observations as regard to this are yet available.

and ovipositing both on old growth and new growth needles. There is no reason for confusing *pinifoliae* with this second species as the discussion of the latter will make plain.

On May 19, 1908, I found *Chermes* pupae common on terminal shoots of white pine. My notes for this collection read: "The pupae are massed close to the tip of the stem or at the base of needle cluster on some stems, and on others they occur singly at the same locations. They are downy enough to be noticed but are not very flocculent."

I collected a considerable number of twigs and the next day many of the pupae molted and an abundance of winged adults were secured. These I listed at the time as *pinifoliae*, and on going carefully over this preserved material this fall I can see no reason to separate it from the species which matures in the black spruce gall about the middle of June. Antennal, wing, and leg characters are apparently identical and the gland areas are so faintly indicated as to ally it with this species and separate it from any other taken in Maine.

These mid-May *Chermes pinifoliae* are, I believe, the return migrants from pine to spruce, but I have not observed this migration. They are not the generation that oviposites on the pine needles, however, as this is done by the migrants from the spruce. This collection, May 19, it will be seen, is in accordance with Fitch's statement that he had "noticed the same insects on the leaves in full life and vigor the middle of May."

It will be seen from the dates of the migrants that either the time which *pinifoliae* spends on the spruce is very short—four to six weeks—or that a two year cycle is required. It is not at present possible to say which is the case.

The galls are uniform, regular, and cone-shaped in form. In length they vary when full grown from about three-fourths to one and one-half inches. Under the stimulation of the *Chermes* the new growth at the tip of the twig is modified and the twig tip develops into a cone-shaped object. The stem itself is not much swollen. Each needle becomes a scale, broadest at the middle and concave on the inner surface. Beneath each scale-like leaf a single *Chermes* develops. Packard states that in the gall of *abieticolens* "each leaf bud is enlarged having an *Adelges* under it" which statement in itself would distinguish

such a gall from that of *abietis* each cell of which contains not "an" but many individuals. A single gall of *pinifoliae* not under average size which I dissected was found to be composed of 139 scale-like leaves under each of which was a single pupa.

The gall when young is slender, about the same length as the young cone and often about the same purple color. Fig. 129 shows a black spruce twig with a single young cone at *A*, the tip of which is unfortunately broken; at *B* are four normal spruce tips; at *C* are four young galls of *pinifoliae*. This photograph shows very well the distinguishing feature of these three growths, the normal shoot, the modified shoot or *Chermes* gall, and the normal cone.

Fig. 128 shows a fully developed gall which at this stage is green. After the galls lose their first purple color they remain green until the time of the emergence of the migrants. Fig. 130 shows the normal cone at *A* which at this stage is purple, at *B* the normal shoot which is green, at *C* the deserted gall which is bright reddish brown. After the gall is deserted the gall leaves flare out from the stem, leaving the chambers open wide. About this time the gall becomes a bright reddish brown, that is the galled terminal shoot dies in this characteristic way.

Pupa. The full grown pupa (June 14) is dark reddish brown with thorax somewhat lighter than head and abdomen. Legs and antennae dusky. Body lightly threaded with short wax fibers, giving body a downy appearance.

Winged Female. Fig. 108. The newly molted migrant, before the wings are expanded, is glistening reddish brown with pelucid legs and antennae. The crumpled wings are distinctly yellow. The wings when expanded are smoky, the stigmal region is yellowish or reddish brown. The migrant by the time it has reached the pine needles is very dark, with "its abdomen dusky red and slightly covered with fine cottony down." The antennae and legs are dark. In size these migrants vary greatly as indeed do all the *Chermes* listed in this paper. The total length of body of this form ranged from 1.7 mm. to 2.9 mm. (.066 in. to .11 in.) the latter measurement being for the larger individuals with their abdomens fully extended. The wing expanse varies also, the average being about 8 mm. There

is nothing especially striking in regard to the venation. The characteristic curves of the veins have been faithfully reproduced (Fig. 108). At the junction of Sc with costal margin the wing creases a little and a decided angle occurs at that point in the wings of this species except when they are newly emerged. This angle is more pronounced for this species than any other of these Maine species, though the same tendency is often shown by others to a slighter degree. The drawing was made from a wing of a newly emerged individual and this costal angle not indicated.

The most distinctive characteristic in the wings of *pinifoliae* is the decided arch of the costal margin of the fore wing and the almost circular curve of the hind margin of the hind wing. The shape of the wings alone would separate this species from the other five developing in spruce galls in Maine. Packard's figure of *abieticolens** gives the characteristic outline of this peculiar wing which alone would serve to separate it from *abietis*. The legs are very stout.

The antennae (Fig. 109) are 5-jointed, the segments stout, III, IV and V are approximately subequal in length. III and IV resemble each other closely both as to shape and sensorial areas. V has the curve of the outline less abrupt, and the sensorial area larger. Terminal hairs four or five in number and slender (Fig. 109a). The sensorial areas as well as the shape of segments and reticulations are shown in the figure of antenna more distinctly than verbal details could indicate.

The wax pores of this species are more difficult to find than on any of the other species recorded in this paper. Even in specimens fairly well cleared the gland areas were not always evident. However, from a large series of mounts of specimens cut transversely giving the clearing fluids every opportunity, the gland areas (Fig. 108) were found to be consistently as follows: head with an area of two transverse groups on anterior margin nearly coalescing, an area of two transverse groups at posterior margin; prothorax with an irregular lateral area, a median anterior area of two groups, and a row of 4 groups near posterior margin; mesothorax with a lateral group on anterior margin and a median area of two groups on posterior portion

* Insects Injurious to Forest and Shade Trees.

of the lobes; metathorax with a median area of two groups corresponding to the median rows of the abdomen; abdomen with median area in two groups (or frequently merging) on segments 1-7, and a lateral group on segments 1-9 (merged on the ninth). In addition to these there occurs between the lateral and median groups on segments 1-4 a very small group of two or three pores usually separate from the median pores, but sometimes merged with them. Most, if not all, of these wax pores would easily be overlooked and the fact that this species has its abdomen only "slightly covered with fine cottony down" indicates that the glands are not so functionally active as those of other species.

Remedial Measures. There would seem to be no practical method of combatting this insect in forest growth. With ornamental trees, however, the galls could be removed from the black spruce previous to the emerging of the winged form. Also if the species proves constantly troublesome it might be desirable not to plant the white pine in the vicinity of black spruce and *vice versa*.

Spraying with whale-oil soap (1 pound to 2 gallons of water), would probably destroy the young on the white pine shoots, but it is doubtful that this would be usually worth while in Maine where *Syrphus* flies abound. The larvae of these, little light colored maggots, have been found to feed industriously on the young *Chermes*. So numerous are these beneficial maggots at times in the midst of the white waxy secretion of the *Chermes* that they are sometimes mistaken by people submitting them for determination as the cause of the trouble.

Note: The foregoing evidence will make it clear enough that Shimer was in error in considering the winged specimens which he reared from *pinicorticis* to be *pinifoliae*. That Shimer found winged *pinicorticis* "very plentifully" on the pine leaves would be natural enough for at the time of emergence the winged forms are sometimes abundant on all parts of the tree. I have seen them in considerable numbers resting on pine needles apparently just before flight, but never fixed as described by Fitch as characteristic of *pinifoliae*. Observers of *pinicorticis* have accepted Shimer's conclusions that his *Chermes* .025 inches long which he bred from pupal *pinicorticis* was the same as *pinifoliae* described as .08 inches long, in spite of the fact that they have had to contradict Fitch's explicit observations in regard to the very characteristic habits of *pinifoliae*. With the meagre descriptions of the early aphid records many such mistakes are scarcely avoidable, in absence of the species

itself. Fitch's comments on *pinifoliae*, however, are distinctive enough so that with his species in hand it no longer seems "singular" and "unfortunate" that he described *pinifoliae* as distinct from *pinicorticis*, but rather singularly interesting that this species had not been rediscovered long ago.

To see that Fitch's much discussed description of the wing of *pinifoliae* agrees with fig. 108 it is only necessary to translate it to modern parlance "The rib vein (Rs) runs straight to the outer margin forward (proximad) of the tip, it gives off from its middle on the outer side a very oblique branch (Sc) which runs to the outer (costal) margin, its tip producing a slight angular projection* to the edge of the wing, and the whole space (stigma) on the outer side of the rib vein (Rs) beyond this branch (Sc) is more opaque than the rest of the wing and of a smoky yellowish color. From its inner side the rib vein (Rs) sends off three simple oblique veins, the last one (M) of which ends in the extreme tip of the wing. The hind wings have an angular point (for hooks) on their outer side (costal) beyond the middle, and a longitudinal rib-vein (Rs) which forward (proximad) of its middle sends off a branch (M) almost transversely inward (caudad) with its tip curved backward (distad)."

- 1858. *Chermes pinifoliae* Fitch. *Trans. N. Y. St. Agr. Soc.* for 1857, Vol. 17, 1858, p. 741. Republished in 4th *Rep. Ins. of N. Y.* 1859 p. 55.
Description of winged form.
- 1862. B. D. Walsh. *On the Genera of Aphididae Found in the U. S.* Species listed only.
- 1869. Henry Shimer. *Trans. Am. Ent. Soc.*, Vol. 2, p. 384.
Winged forms of *pinicorticis* mistaken for *pinifoliae*.
- 1879. Cyrus Thomas. *Eighth Rep. St. Ent. of Ill.*, p. 156.
Quotes Fitch's description.
- 1881. A. S. Packard. *Insects Injurious to Forest and Shade Trees*. p. 118. From Fitch.
- 1884. Herbert Osborn. *Bulletin No. 2. Iowa St. Agr. Coll. Dept. of Ent.* Follows Shimer's error in considering winged *pinicorticis* to be *pinifoliae*.
- 1885. J. A. Lintner. 2nd *Rep. St. Ent. of N. Y.*, p. 180-187.
Follows Shimer's error in considering winged *pinicorticis* to be *pinifoliae*.
- 1890. A. S. Packard. *Fifth Rept. U. S. Ent. Comm.* p. 805.
Fitch's description quoted, without comment.

* See page 286 for comment.

1898. Storment. *Rept. Ent. Ill.* 20; iii-xxiii. Follows Shimer's error in considering winged *pinicorticis* to be *pinifoliae*.
1901. W. D. Hunter. *Iowa Agric. Coll. Exp. Sta. Bull.* 60. *The Aphididae of North America*. Lists *pinifoliae* as a synonym of *pinicorticis*.
1909. Edith M. Patch. *Annals of the Ent. Soc. of Am.* Vol. II. No. 2. Discussion of tracheation of wings of *Chermes pinifoliae*. Pp. 107, 111, 116 and figs. 26-30.
1909. Edith M. Patch. *Me. Agric. Exp. Sta. Bul. No.* 171. Economic treatment giving main features of life history of *pinifoliae* and stating that *abieticolens* is the gall generation of the same species.
1909. Edith M. Patch. *Psyche* Dec. 1909, pp. 136-137.

Chermes abieticolens.

1869. A. S. Packard. *Guide to the Study of Insects*, p. 522. Brief description with figures of this species recorded as a species of *Adelges* occurring in abundance on the spruce in Maine. Some good characters of gall also given.
1879. Thomas. *Rept. Ent. Ill.* 8: (III of Thomas) p. 156. Species named provisionally as *Chermes abieticolens* and statement made that it is certainly distinct from *abietis*. Refers to Packard.
1885. J. A. Lintner. *2nd Rep. St. Ent. of N. Y.*, p. 185. Refers to Packard and Thomas.
1887. Oestlund. *Aph. Minn.* Species listed.
1890. A. S. Packard. *Fifth Rep. U. S. Ent. Comm.* *Adelges abieticolens* Thomas. Original account and illustration copied.
1897. Fernald and Cooley. *34th Report Mass. Agric. College*, pp. 89-100. *abieticolens* merged with *abietis* by error on the basis that in response to "about five hundred circular letters sent to different persons in the U. S. and Canada, only one species of *Chermes* was received." Excellent account of *abietis*.

CHERMES ABIETIS Chol.

This common European species has been variously designated as "The Spruce Gall-louse"* , "The European Spruce Bud-louse"† , "The Yellow Chermes"‡ , "The green-winged Chermes"** and the gall has been aptly called the "pine-apple gall" on account of its form.

This species has been for a good many years annually abundant on the Norway and white spruces on the campus of the University of Maine. I have collected the gall and the insect at various stages frequently since the fall of 1903, without giving the species any especial study except to compare my own observations with published accounts.

Confusion in the literature of this species both in this country and in Europe has existed on account of other species having been confounded with it. Because of this it may not be out of place to present my own notes, though probably containing no new observations, in connection with the photographs of the galls and the drawings of the species which they concern.

The Gall. Fig. 137. The galls of *abietis* vary in size from about $\frac{1}{2}$ inch to 1 inch or more in length. They occur at the base of terminal shoots and do not as a rule kill the twig. Where they are numerous they cause serious deformations of the branches, and small trees are sometimes ruined by their presence. Such galls are not only very abundant on Norway spruces but they are troublesome on the native white spruce in Maine. This season (1909) a single white spruce 3 feet tall had more than 990 fresh galls upon it. The growing galls are green, with the closed mouths of the cell marked by a Δ -shaped red line. The shade of this line varies from purple to brick red in different galls and at different times. The galls resemble in form a little pine-apple, each section being represented by a needle much enlarged at the base and little if at all at the tip. The relation of the galls to the twig on which they grow is shown in the longitudinal sections in Figs. 138 and 139. It will be seen that in some cases the gall entirely encircles the twig which

* 34th Report Mass. Agric. College.

† Packard, 5th Report of Ent. Comm. page 853.

‡ Die Coniferen-Läuse Chermes. Prof. N. Cholodkovsky. 1907.

** Me. Agric. Exp. Sta. Bul. 171.

continues its growth from the apex of the gall, while in others the gall is produced in a one sided manner only partly encircling the twig. The cells of the gall are closed. A sample gall about $\frac{1}{2}$ inches long contained about 50 cells each holding from 8 to 12 nymphs. This count was made August 13.

About the middle of August at Orono the mouths of the cells open and the pupae emerge to molt.

Nymphs, the Gall Generation. Specimens taken from galls June 23, 1904, are recorded as greenish yellow. July 24, 1909, nymphs are recorded as very pale yellow covered with white pulverulency. Molted skins attached to caudal extremity were filled with liquid so as to retain their shape. Many nymphs had two such molts attached so that three successive stages of the insect were in line. The excreted liquid being largely disposed of in this manner, the cell wall of *abietis* is clean and dry, a condition made further possible by a slight covering of waxy powder.

Pupae. Body length of full-grown pupa 1.9 mm. Specimens taken from galls on Norway spruce August 4, 1909, were very pale yellow, slightly pulverulent. Others taken from galls on white spruce August 17, 1909, were a little darker yellow and the finely-pulverulent abdomen had a slight rosy tint. The pupae leave the galls before molting. The time of most plentiful emergence is from about the middle to the last of August for the vicinity of Orono, though the galls in more exposed sunny places are about a week earlier in opening than the average shaded ones. The pupae creep from the open cells of the galls in a sluggish manner and often rest in Indian files on the needles near the gall, where they molt and become the winged individuals. The cast skins remain in white rows upon the needles for some time unless dislodged by rain. See Fig. 140.

The wax pores for the pupa are: (Fig. 117) head with an anterior group of pores near base of each antenna and two median groups at posterior margin; prothorax with lateral gland area, an anterior median pair of groups, a small group (4 pores) between the lateral and median ones, and four groups near posterior margin of prothorax; mesothorax with an anterior lateral area; metathorax with two separated median groups; abdomen with small and widely separated median groups on segments I-VI, those on I being composed of about 6 pores,

those on II of 3 and those of III-VI of 2 each, a very small group of lateral pores occur on segments II-IX (merged to a caudal group on IX), and about half way between the median group and lateral margin an additional group of about 3 pores occurs on segments I and II. The smallness of these inconspicuous groups is correlated aptly with the fact that this is not a flocculent species, the wax secretions not exceeding the pulverulent condition. Fig. 117 shows a pupa a short time before the final molt.

Winged Oviparous Form. Fig. 115. The freshly molted individuals, August 19, 1909, have a golden brown body, the thorax, except the dorsal lobes, slightly lighter than abdomen, lobes of thorax dark, head dark, wings with whole stigmal area and margin a decided and conspicuous green, the remainder of the wing being white with a slight yellowish green tint. As the individual ages the coloring becomes darker, though the wings retain their characteristic green color. Length of body 1.7 to 2 mm., wing expanse 6 mm.

The areas of the wax pores (Fig. 115) are much as in the pupa except for the abdomen which is as follows: I with median groups comparatively large and merged, II median groups separated and composed of 2 pores each, V with two small groups between median ones referred to. I-VIII with distinct lateral groups on darkened area, III-VI with small groups of 2 or 3 pores each midway between median and lateral groups.

The wing veins of this species have, as with the other five discussed in this paper, a fairly constant characteristic trend which is shown in Fig. 115. First A of the fore wing is seen to be considerably arched.

The sensorium of each of antennal joints III-V is confined to the distal half of the joint and extends not more than half way around the joint. These three joints are much alike in general appearance. III is noticeably shorter than IV while IV and V are subequal. The usual group of smaller sensoria occurs on V and there is nothing striking about the 4 or 5 terminal hairs. Fig. 116.

Apterous oviparous form—winter female or stem mother. May 7, 1906, I observed these young females of the winter generation, minute and slightly downy clinging close to the buds or in the axle of the leaves on Norway spruce. May 31, 1906,

the females were very plentiful and were readily detected on account of the little white flocculent mass surrounding her and her recently laid eggs. One such egg cluster contained about 140 eggs and the female was not through ovipositing.

The life cycle for abietis based upon the writer's observations is briefly as follows: Galls open about mid-August and fully grown pupae emerge and molt within a few hours becoming the winged form which deposits a cluster of 40 to 50 yellow eggs on a spruce needle. The eggs are extruded from the abdomen but the parent *Chermes* remains over them until dislodged after her death by wind or rain. The winged form often oviposites near the gall from which it emerges. A different species of host plant is never sought by this *Chermes*. In about two weeks the young "stem mothers" hatch from these eggs and seek a protecting crevice in the surface of the spruce bud where they can spend the winter. These wingless forms develop in the spring and become full grown about the last of May when they lay a cluster of 140 or more eggs. From these eggs hatch the young that inhabit the gall and are known as the "gall generation" with which we started the cycle.

For a further account of *abietis* the reader is referred to the 34th Report of the Mass. Agric. College, 1897, and to *Dic Coniferen-Läuse Chermes* by Prof. N. Cholodkovsky, 1907.

Remedial Measures. Spraying the trees in April with whale-oil soap solution (1 pound to 2 gallons of water) has been reported as effectual. (34th Report Mass. Agric. College). The practice of removing and burning the galls will serve to control this species sufficiently on ornamental trees. At Orono great numbers of the winged forms are caught in spiders webs that are spun irregularly over the spruce twigs.

Bibliography. It does not seem practical to attempt a bibliography of *Chermes abietis* for United States. That various other *Chermes* have been confused with this species is certain, but to what extent it is often impossible, on the basis of the references, to be sure. The illustration in Bulletin 56, West Virginia Agricultural Experiment Station 1899 of the "Galls and deformed twigs of the spruce gall louse" (Fig. XXXI, page 261) does not figure galls of *Chermes abietis* but those of some other *Chermes*, possibly of *similis*.

In the Spruce Gall-louse *Chermes abietis* Linn. by Fernald and Cooley (34th Report Mass. Agric. College, 1897) is pre-

sented carefully the life history and habits of this species. The figure of the gall Plate II in that paper is the characteristic *abietis* gall and the wings on the same plate show the typical curves of the veins of this species. The record of *abietis* from Colorado (page 4 of Author's separata p. 92 in 34 Report) however applies to *Chermes cooleyi* (See Gillette *Chermes of Colorado Conifers* page 3), and *abieticolens* of Packard and Thomas is by error in that publication considered to be the same as *abietis*.

CHERMES LARICIATUS Patch.

A gall resembling that of *abietis* very closely in size and form and found, like that of *abietis*, on white spruce was taken in the vicinity of Orono by Mr. William Woods, July 28, 1909. Fig. 141 shows two of these.

The galls. Like the galls of *abietis* they are not terminal on the twig and the tip of the twig extends out from their apex when they encircle it, or along one side of the gall when they do not, just as with *abietis*.

The galls were mature on date of collection. The needles of the gall are green at this season. Conspicuous wide russet lines mark the closed mouths of the galls which gives the gall a general russet color. The needles of the gall are much shorter than is usual with *abietis* on the Norway and White spruces and it is thus a little more pine-apple like in form than *abietis*. Many of the galls were opening at the time they were collected, and the pupæ walk out from the open cells before they molt, as do *abietis*. The galls become dry and brown soon after they are vacated. The cells are not as shallow as those of *abietis*.

The pupa. (Fig. 122). Described from forms just leaving the gall before the last molt. Length of body 2 mm.; head, prothorax and abdomen light reddish; thorax yellowish green; wing pads dark green; ventral prothorax and thorax yellowish green; legs and antennae greenish. The areas of wax pores are well defined; head with anterior area between antennae, and four posterior groups; prothorax with a large lateral area, an anterial row of 4 groups, a posterior area of 2 groups, and a broken line of 4 groups between the anterior and posterior groups; mesothorax with a very large anterior lateral area and a row of 4 groups across the middle of the segment; metathorax with a very large lateral area about the size of that

of the mesothorax, and a row of 4 well defined and separated groups which are in line with those of the abdomen; abdomen with lateral groups on I-IX (merged to caudal group on IX), I-VI with a dorsal row of 4 groups on each segment, the median ones being largest but not merged.

The Winged Oviparous Form. Migrant. (Fig. 118). Newly molted individuals have prothorax and abdomen light yellowish brown, head and thoracic lobes dark, legs and antennae greenish, wings decidedly green with yellow proximal portion. The individuals, of course, grow darker as they age. Body length about 1.9 mm.; wing expanse 6 mm. to 6.2 mm.

The well defined areas of wax pores are: head with 2 distinct anterior groups and 2 large and separate posterior groups; prothorax with the usual lateral area, a row of 4 anterior groups, and 2 posterior groups widely separated; mesothorax with two median distinct groups; metathorax with two median groups separate and in line with the median groups of the abdomen; abdomen with median groups on segments I-VI well defined and widely separated, well marked lateral groups on segments I-IX (merged to caudal group on IX), and a small group between the lateral and median groups on III-VI.

The antennae (Fig. 119), is more like that of *abietis* than any of the other species of this paper, but the outlines of the joints are less abrupt, the curves of the sensoria are more regular, and V is typically longer than IV. III and IV are about sub-equal.

The wings resemble those of *abietis* but are distinct enough. 1st A of the fore wing of *lariciatus* is less strongly arched and M of the hind wing is a heavier vein than that of *abietis* and strongly curved with the convexity distad.

July 31, 1909, this species was found to be common on the needles of larch everywhere in the vicinity of Orono. The migrants from the white spruce galls settled on the larch needles and oviposited. The eggs are extruded and not retained in the abdominal cavity as with *pinifoliae*, and the parent is more easily dislodged even than *abietis* and soon drops from the egg mass. There are from 50 to 75 beautiful green (paler than larch green) eggs in a cluster. (Fig. 121). They are slightly pulverulent. The glimpse through a glass at this little *Chermes* with the green eggs showing through her transparent wings

is one of the prettiest sights of the insect season. Fig. 120 gives the position of this species when oviposition is nearly finished. The migrants settle on the larch needle either with head toward base of needle or toward tip, apparently indifferently.

On July 31, 1909, opening galls of this species were placed upon sprigs of conifers in cage. The twigs were in vials of water so that they remained fresh. On August 3 the individuals that oviposited were counted with the following results:

<i>Picea rubra</i> Dietr	Red spruce	0
<i>Picea mariana</i> (Mill.) B. S. P.....	Black spruce	0
<i>Picea abies</i> (L.) Karst	Norway spruce	1
<i>Picea canadensis</i> (Mill.) B. S. P.....	White spruce	4
<i>Pinus strobus</i> L.....	White pine	0
<i>Pinus sylvestris</i>	Scotch pine	0
<i>Thuja occidentalis</i> L.	Arbor Vitae	0
<i>Abies balsamea</i> (L.) Mill.....	Balsam fir.....	4
<i>Larix laricina</i> (Du Roi) Koch.....	Larch	69

The preference for larch speaks for itself. Whether the other ovipositions have any significance or are merely accidental it is, on the basis of this one test, impossible to say.

Whether *lariciatus* may be the same as *laricifoliae* Fitch I have not been able to decide. There is nothing in the brief description of Fitch's to preclude this possibility. Fitch's color description does not agree in all respects with my notes for *lariciatus* but these were made from specimens immediately after molting and would not be the same as an older specimen. The italicized portion of the original description for *laricifoliae* Fitch which is here quoted entire would apply very well to *lariciatus*. "Solitary and stationary upon the leaves, extracting their juices, small black shining flies 0.10 (inch) long, having the abdomen dark green, the legs obscure whitish, the wings nearly hyaline with pale brown veins and the large stigma-spot upon their outer margin beyond the middle more opaque and pale green. This is closely like the Pine Chermes, No. 267, but has the wings more clear, and differs also in some of the details of its colors."

So far as I can judge some of the records referred to *laricifoliae* in this country really concern *consolidatus* which is certainly not *laricifoliae* Fitch. It is not improbable that *lariciatus*

may prove to be the European *viridis* Ratz. as discussed by Professor Cholodkovsky in *Die Coniferen-Läuse*, 1907. The galls of *viridis* Figs. 1 and 8 in that publication very well picture the galls of *lariciatus* and the host plants are identical.

As the specific characters on which I have laid most stress, antennae, wings and wax gland areas of the winged forms, are not given in so much detail in European publications as the structure of the apterous forms, the figures do not emphasize the same points and the only basis for comparison would be determined European material which may perhaps be possible to secure.

CHERMES CONSOLIDATUS Patch.

July 20, 1909, in the vicinity of Orono Mr. William Woods collected from black spruce some pink and green galls resembling those figured by Professor Cholodkovsky in *Die Coniferen-Läuse Chermes* 1907 for *Chermes strobilobius* Kalt. The flesh of the gall on the surface is a delicate pink, the needles of the gall, much stunted, are a delicate green. Some of the galls collected on the same day were pale green instead of pink. The galls (Fig. 145), are about one-half inch long or less and are terminal. The cells of the galls contained dark red nymphs which were flocculent rather than merely pulverulent, and the cell walls were also covered with the flocculent secretion.

Specimens began to emerge from these galls in the laboratory July 30, and galls found out of doors on red spruce were opening about the same time.

Opening galls of this species were placed in a cage on twigs of red spruce, black spruce, white spruce, Norway spruce, arbor vitae, white pine, Scotch pine, hemlock, balsam fir and larch. In a few days a count of ovipositing individuals was made and it was found that they had laid eggs *very sparingly* on each of the four spruces and balsam fir—1 to 5 specimens on each plant. 9 to 12 eggs were deposited in a mass under the wings. Most of the individuals died without ovipositing at all. This test certainly gave no dependable data, nor did I chance upon this species ovipositing out of doors. The galls in this vicinity were not numerous and the species is very small.

I have taken, however, on June 20, 1909, and about the same time previous years small *Chermes* pupae developing at the

base of larch cones in flocculent matter. When these molt they prove to be brown bodied with a caudal flocculent tuft and greenish wings. These winged forms I am unable to separate on microscopic comparison from *consolidatus* (Figs. 123 and 124), and think that there is no reason to doubt that they are the same species, and that the larch and spruce are alternate hosts of *consolidatus*.

Whether they prove to be *strobilobius* Kalt. can only be ascertained by comparison with authentic European material which is not at present available.

Pupa. The pupa, described from specimens removed from spruce galls. (Fig. 125). Body dark red and flocculent, the larger ones 1.2 mm. long. Areas of dorsal wax pores; head with large groups at anterior and posterior margin; prothorax with lateral areas, a row of 4 large anterior and 4 large posterior groups; mesothorax with a curved transverse row of six well defined groups, the outer ones forming the usual anterior-lateral groups, metathorax and abdominal segments I-VI with transverse rows of 6 groups each, VII-IX with only the marginal group. Fig. 125 was drawn from a pupa in its last stage but sometime before it molted. Later the conspicuous circular space about the gland openings is not so discernable.

The Migrant from the Spruce Gall. (Fig. 123). Length .9 mm.-1.3 mm.; wing expanse 3.5 mm.-4.0 mm. The wings of this species are very rotund. The veins in the fore wing are usually like those given in fig. 123 though frequently they are straighter. M in the hind wing usually curves with the concavity distad though sometimes this vein is nearly straight.

The most striking structural distinction between this and the other 5 spruce *Chermes* is in the antennae. The constrictions between joints III, IV, V are very inconspicuous so that these joints from some positions appear almost to be consolidated into a single long terminal joint. It was this character that suggested the specific name. The antennae of *consolidatus* are distinctive in one other respect, two of the four terminal hairs are developed into strong spines (Fig. 124a). This is not true of any of the other 5 spruce species.

Apterous oviparous form on larch.

On August 1, 1909, apterous oviparous forms in woolly mass on larch twigs were common. Although the connection was not traced I believe these to be *consolidatus* Fig. 126 was drawn from one of this collection.

CHERMES FLOCCUS Patch.

Like *Chermes pinifoliae* Fitch, this species develops in galls on black and red spruce and migrates to the needles of the white pine to oviposit. Both the galls and the insects, however, of these two species are too distinct to be in any respect confused.

These galls (fig. 134) were first collected on black spruce at Orono, July 10, 1909. They resemble galls of *similis* Gillette but are more compact and better formed than any galls of *similis* which were taken this season in Maine. They occurred in great numbers in this vicinity on red and black spruce. They are terminal and comprise the total deformed shoot. In length they vary from about $\frac{3}{4}$ to $1\frac{3}{4}$ inches. The surface of the gall is green in some while some have a dark purple tinge near the base of each needle, giving the gall a purple cast. The needles of the gall are not much dwarfed and are a normal spruce green. Figs. 135 and 136 give cross and longitudinal sections of this gall.

On account of the loose structure of the gall, syrphus maggots were very abundant within, feeding on the *Chermes* nymphs.

The pupa remains within the gall until after the last molt and the winged migrant emerges ready for flight.

Pupa. (Fig. 112). Described from specimen removed from gall shortly before the last molt. Length of body about 1.8 mm. Head, antennae, wing pads and legs dark or dusky, prothorax and abdomen rather dull reddish, thorax yellowish red and paler than abdomen. Entire body pulverulent. Wax gland areas on prothorax, thorax and abdomen are plainly located under a Zeiss binocular, by warty appearance of live specimen. These areas are: head with 2 large anterior and 2 larger posterior groups; prothorax with prominent lateral groups, also 2 small median anterior groups and 2 large posterior groups; mesothorax with prominent lateral areas, large median groups

and small anterior groups; metathorax with 2 median groups in line with these on head and pro- and meso-thorax and abdomen; abdomen with lateral groups on segments I-VIII, large median groups on segments I to VI and a row midway between the lateral and median groups on I to VI. None of the pore-groups are merged in the pupa.

Migrants from spruce gall to pine. (Fig. 110) 1.5 mm.-2.1 mm. long with wing expanse 5.0 mm.-5.6 mm. Freshly molted individuals have a yellowish red body and pale buff wings. The antennae are characterized by the exceedingly large sensoria on joints III, IV, V. Each sensorium comprises the entire surface of the joint except the extreme proximal and distal portions and a narrow ridge connecting these. The constrictions between joints are abrupt. III and IV are subequal and V is longer and not so thick. The wings are rather narrow. 1st A in the fore wing curves, the convexity being distad. M of the hind wing curves, the concavity being distad. Large wax gland areas occur on head and the three thoracic segments. On the abdomen lateral groups are present on perfectly distinct darkened areas on segments I-VII, IV, V, and VI are transversely banded by wax pores across the dorsum. Merged median groups occur on I, II, III and on III a separate group (sometimes absent) midway between the median and lateral groups. I and II are without wax areas between the median and lateral groups.

These winged forms migrate, from the middle to the last of July near Orono, to pine needles where they oviposit. (Fig. 133.) The ovipositing females secrete considerable wax from head glands as well as over the rest of the body so that they are a decidedly flocculent and not pulverulent species. This character alone would distinguish them from *pinifoliae* and is chosen for the specific name on that account.

In the woods these migrants were found abundant on the white pine needles over egg clusters of about 40 eggs. Coming so much later in the season *floccus* finds both old and new growth pine needles available and deposits the egg mass indifferently on the old or new. *Pinifoliae* migrants occur in this region only on needles of previous years growth as they appear the middle of June.

Chermes floccus migrants are not so particular as *pinifoliae* as to which way they are headed, some migrants settling on

the pine needles with head toward the tip and some with head toward the base.

Besides the out-of-door observation of the migrants on white pine, a laboratory test was given. July 19 a lot of galls from which *floccus* were emerging were placed in a cage among the following conifers which were kept fresh in vials.

July 21 migrants had settled and deposited egg clusters as follows:

<i>Picea mariana</i> (Mill.) B. S. P.....	Black spruce	0
<i>Picea rubra</i> Dietr.....	Red spruce	0
<i>Picea abies</i> (L.) Karst.....	Norway spruce	0
<i>Picea canadensis</i> (Mill.) B. S. P....	White spruce	5
<i>Abies balsamea</i> (L.) Mill.....	Balsam fir.....	0
<i>Tsuga canadensis</i> Carr.....	Hemlock	0
<i>Pinus laricio</i> Poir.var. <i>austriaca</i> Endl	Austrian pine	0
<i>Pinus sylvestris</i>	Scotch pine	0
<i>Pinus strobus</i> L.....	White pine	92
<i>Thuja occidentalis</i> L.....	Arbor vitae	0

July 21, two small tips of white pine alone were put with *floccus* galls. In 48 hours 57 *Chermes* had oviposited on one and 117 on the other. These eggs began to hatch July 28.

CHERMES SIMILIS Gillette.

On July 9, 1909, my attention was called to some scraggly twigs of Norway spruce which proved to be deformed by *Chermes*. These galls resemble somewhat those of *floccus* but they are less regular. Fig. 142 pictures these. Winged specimens were emerging from these galls on date of collection. A search of white, red and black spruces resulted in taking the same galls on all these. These galls are very loose in structure and syrphus maggots freely helped themselves to their contents.

Galls from all these spruces contained pupae practically ready to molt and become the winged form, and also a few very small apterous oviparous individuals which were laying clusters of eggs in little woolly masses. These apterous forms were also found with their eggs in woolly masses along the stem and in one case on the outside of gall of *floccus* (fig. 134.) They were reddish brown and were .5 mm. to 1.0 mm. long.

The winged forms from the Norway spruce out of doors were migrating. On the other hand, the winged ones from

black spruce galls were settling and ovipositing freely on black spruce. They are a flocculent species and their wings showed dark against the woolly mass which covered their abdomens and egg clusters.

What the life-cycle relation of the apterous oviparous forms is to the migrants appearing and ovipositing at the same time I do not know. They are here considered as *similis* though their identity is not proven. The galls of *similis*, however, were the only ones discussed in this paper in which apterous oviparous forms were found. Professor Gillette also records apterous females and their egg clusters to be present in galls of *similis*.

A cage test as to preference of spruces of the migrants was made. July 9, galls from black spruce were caged with uninfested black, white and Norway spruces. By July 13 a few migrants had settled on the Norway and deposited but a decided preference was shown for the white spruce upon which they settled in plentiful numbers and deposited eggs, remaining for a time on the little white woolly masses.

July 9, galls from white spruce were placed with uninfested white, black and Norway spruces. A large majority chose the white spruce. The eggs of this species hatched in about a week.

On trees where the infestation was heavy the terminal shoots were sticky and the needles somewhat ruffled. (Fig. 144). In many places portions of the spruce needles turned whitish yellow giving a "blighted" appearance to the shoot.

The winged form (fig. 113), varied exceedingly in size, part of the emerging ones being about 1.0 mm. long with a wing expanse of 3.0 mm.-4.0 mm. while the majority were larger, ranging from 1.45 mm. to 1.7 mm. with a wing expanse of about 4.8 mm. Color of body reddish brown, wings a little smoky. Wings much as in *floccus* with the veins having a little more tendency to straightness. Antennae are more like those of *pinifoliae* than any other, both as to general shape of joints and the relative size of the sensoria. The wax gland areas are: head with dorsal surface nearly covered by the two anterior and posterior groups which nearly meet; prothorax with large lateral area, two anterior and two posterior groups; mesothorax with lateral anterior group and two very large median

groups; metathorax with median groups extending nearly across the segment; abdomen with large groups on I-VI, median groups on I-VI being largest on I and graduated to smallest on VI; a group of wax pores midway between the median and lateral series on segments II-VI, those on IV-VI being much larger than those on I-II (the group on I, of 2 or 3 openings only, is sometimes missing).

Certain striking resemblances of this Maine collection to *similis* as described by Professor C. P. Gillette* led me to submit balsam mounts, galls and illustrations to him. On the basis of this data he stated that he is unable to find any good distinguishing characters to separate this Maine material from *similis*. Professor Gillette's courtesy in determining this species enables me to introduce *similis* from Maine.

CHERMES PINICORTICIS Fitch.

It frequently happens that trunks of the white pine in Maine are more or less covered by the white secretion of this minute *Chermes* which gives the bark a moldy appearance (fig. 146). The infestation has been particularly heavy during 1908 and 1909, but during the latter season so many syrphus maggots were present preying upon the *Chermes* that these natural enemies seem likely to check its increase.

Though I have reared the winged forms of *pinicorticis*, I have made no special study of this species. Whether it confines itself to the pine or possesses an alternate host is not known. I have found the winged forms resting in abundance on needles of infested small white pines, from which they took flight at the slightest jar. Whether their destination was another species of plant or merely another white pine, the present knowledge of this species does not give basis to state.

Either the wing or the antennal characters of *Chermes pinicorticis* would serve to distinguish it from any of the 6 *Chermes* discussed in this paper, though its minute size alone would prevent confusion.

The fullest account of this species is by Mr. Storment published in the Appendix to the *Twentieth Report of the State Entomologist of Illinois*. In Mr. Storment's paper, as in others

* *Chermes* of Colorado Conifers. 1907.

on *pinicorticis* since Mr. Shimer by error merged *pinifoliae* with *pinicorticis* about 40 years ago*, the NAME *pinifoliae* is confused with *pinicorticis* both in the discussion and bibliography. It is evident from the context, however, that neither Mr. Shimer, Professor Osborn or Mr. Stormont had observed the INSECT *pinifoliae* and for this reason the mistake in synonymy is very easily corrected.

CONCLUSION.

The present paper deals with six gall forming *Chermes* of Maine conifers. The gall host and the alternate host, where there is one, has been in each case ascertained. No attempt has been made to follow the development of the winter generation. With three species of *Chermes* making galls on the white spruce and four on black spruce in one locality it is apparent that a detailed study of the winter generations could only be carried on satisfactorily on conifers raised from seed under quarantine.

A glance at fig. 134 where *Chermes similis* is seen ovipositing on galls of *Chermes floccus* is sufficient to suggest the confusion possible.

Both the galls and the winged individuals give characters sufficient to determine these six species, however, and these have been figured in each case.

Illustrations. The photographs published are selected from many taken by Mr. R. L. Hammond and have been a constant aid in recording permanently certain changing phases of the work of these *Chermes*, and have been a necessary part of the study. The drawings were made by Miss Charlotte M. King who spent most of the summer of 1909 at the Maine Agricultural Experiment Station. The structural details for each form figured were worked out independently by Miss King. During the same time the writer studied carefully with each species the arrangement and number of wax gland areas, the character of the antennal sensoria, wing characters and other significant points and the drawings as they stand record both Miss King's observations and my own critical interpretation, no detail that seemed important being left until sufficient material was examined for a mutual agreement.

* For discussion see pp. 277-289 in this present paper.

Technique. At the time these species were studied, live material was available both for the pupae and winged forms. The general form of the individual was sketched first from live material and such structures as could then be ascertained were indicated. Details were studied and drawings completed from balsam mounts. Live specimens in some cases were mounted directly in the balsam and a few desirable results obtained for immediate use. In each case, however, a large series of mounts was carefully made for study, drawings, and photomicrographs. Total mounts were most satisfactory after the general method (modified according to size, readiness of penetration of the fluids, etc.) indicated as follows:

Killed in hot 98 per cent alcohol,
One hour in 80 per cent alcohol,
One-half hour in 98 per cent alcohol,
Ten minutes in 100 per cent alcohol,
Ten minutes in tolu.

Antennal details were taken from head mounts. Wings were in each species mounted separately. Where total mounts did not bring out clearly the wax gland areas of both thorax and abdomen, severed specimens were prepared to facilitate the more rapid and thorough clearing.

This detailed account of the method of preparation is given in order that the character of the material used may be recorded. Certain groups of wax pores, for instance, were not rendered visible in one or two species except in dissected specimens and in most, a large series was necessary to settle the number definitely. Some variation occurs in the size and arrangement of the groups of wax pores, but individuals figured and described represent the typical wax pore areas as they were seen. As the wax pores are often difficult to see the most convenient specific characters will be found in the wing and antennal characters which are distinctive and within slightly varying limits were constant, for the extended collection in this locality at least.

WING VEIN NOMENCLATURE.

For the nomenclature of the wing veins used here the reader is referred to *Homologies of the Wing Veins of the Aphididae, Psyllidae, Aleurodidac, and Coccidae, Annals of the Entomological Society of America*, June 1909.

NEW SPECIES.

It is possible that some of the species described as new may prove to be synonyms of European species, but as the inconvenience of a synonymy is so much less than the confusion of a composite species it seemed wise not to attempt comparison with European species until a careful study had been made of these *Chermes* as they occur in Maine.

The first brief descriptions of *floccus*, *consolidatus*, and *lariciatus* were published in *Psyche*, December, 1909.

CHERMES IN ^{the} EUROPE.

Many important and admirable studies of *Chermes* species have been carried on in Europe by such careful workers as Blochmann, Börner, Cholodkovsky, Dampf, Dreyfus, Mordwilko, Nüsslin. A comprehensive review of this work with bibliography appeared in *Zoologisches Zentralblatt*, Dec., 1909. *Zusammenfassende Übersicht. Die neueren Ergebnisse und Aufgaben der Chermes-Forschung von Prof. O. Nüsslin in Karlsruhe.*

HOST PLANTS.

The host plants in the following key are recorded solely on the basis of one season's careful collection in the vicinity of Orono. The list of host plants may need to be extended later but it is accurate so far as it goes. In recording the collections of the galls, the botanical distinctions between the red and black spruces has been observed, though entomologically these might pass for one species. *Chermes* at any rate does not pay any attention to the distinction.

KEY TO THE CHERMES OF MAINE CONIFERS.

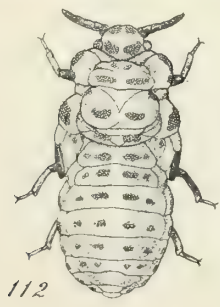
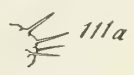
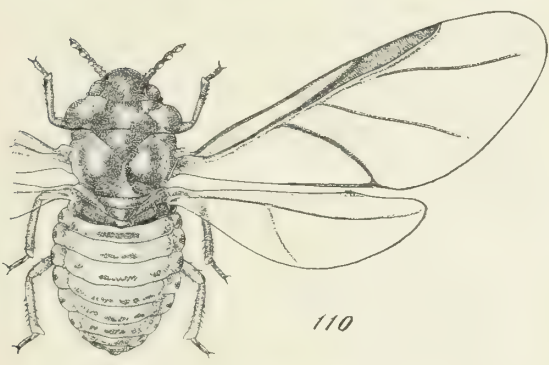
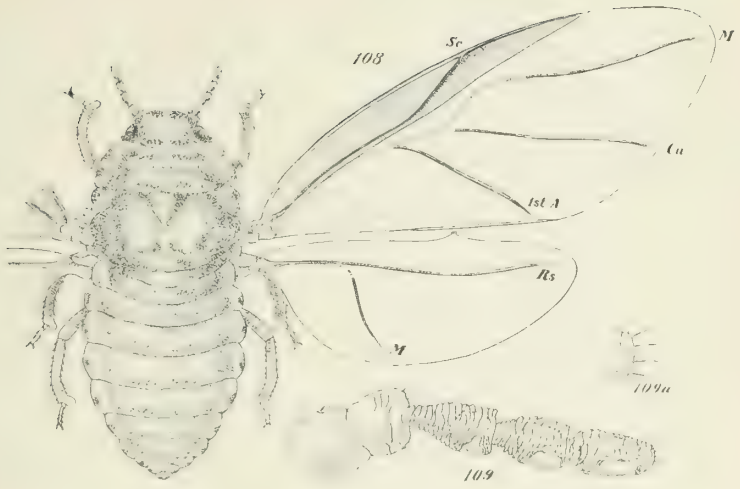
- A. Galls on black spruce (*Picea mariana* B. S. P.) and red spruce (*Picea rubra* Dietr.)
 - Gall terminal.
 - 1. Gall conelike, needles modified to thin scales. Ripening mid-June. Migrants ovipositing on needles of white pine. (*Pinus strobus* L.) *pinifoliae*.

2. Scraggly deformed twig. Gall-needles not much abbreviated. Ripening first of July. Migrants ovipositing on spruce *Picea* sp. *similis.*
 3. Gall usually well formed $\frac{3}{4}$ -1 $\frac{1}{4}$ in. long. Needles not much abbreviated. Ripening mid-July. Migrants ovipositing on needles of white pine. (*Pinus strobus* L.) *floccus.*
 4. Gall small, $\frac{1}{2}$ inch or less, pink or pale green. Gall needles short. Ripening first of August. Species also found on larch (*Larix laricina* Koch.) *consolidatus.*
- B. Galls on white spruce.
- Gall terminal,
Scraggly deformed branch. Ripening first of July. Migrants ovipositing on spruce (*Picea* sp.) *similis.*
- Gall not terminal,
1. Pine-apple shaped. Ripening last of July. Migrants ovipositing on needles of larch. (*Larix laricina* Koch.) *lariciatus.*
 2. Pine-apple shaped. Ripening mid-August. Winged form not migrating to oviposite. *abietis.*
- C. Galls on Norway spruce, *Picea abies* (L.) Karst.
- Gall terminal,
Scraggly deformed branch. Ripening first of July. Migrants ovipositing on spruce, *Picea* sp. *similis.*
- Gall not terminal,
Pine-apple shaped. Ripening mid-August. Winged form not migrating to oviposite. *abietis.*

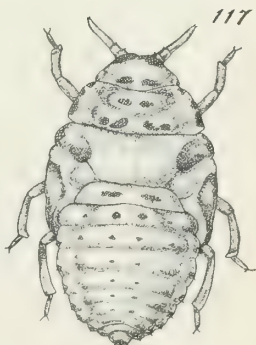
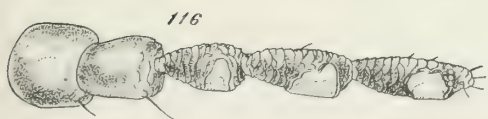
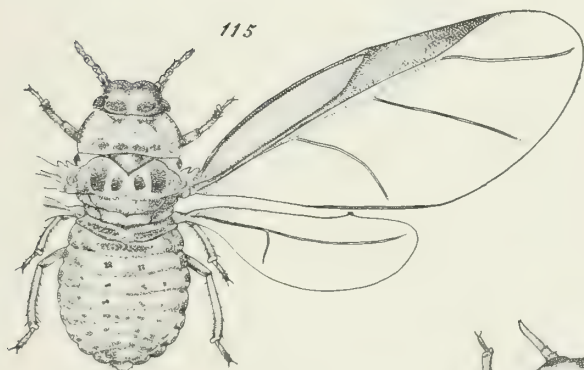
EXPLANATION OF PLATES.

- Fig. 108. *Chermes pinifoliae* Fitch. Migrant from spruce gall to needles of white pine. Figs. 109, 109a. Antenna.
- Fig. 110. *Chermes floccus* Patch. Migrant from spruce gall to needles of white pine. Figs. 111, 111a. Antenna.
- Fig. 112. *Chermes floccus*, pupa developing in spruce gall.
- Fig. 113. *Chermes similis* Gillette. Form which emerges from spruce gall. Figs. 114, 114a. Antenna.
- Fig. 115. *Chermes abietis*. Form which emerges from spruce gall. Fig. 116. Antenna.
- Fig. 117. *Chermes abietis*, pupa developing in spruce gall.
- Fig. 118. *Chermes lariciatus* Patch. Migrant from spruce gall to needles of larch. Figs. 119, 119a. Antenna.
- Fig. 120. *Chermes lariciatus*. Migrant on needle of larch with egg mass nearly completed and showing through the thin transparent wings. Drawn from living specimen.
- Fig. 121. *Chermes lariciatus*. Egg mass on larch needle.
- Fig. 122. *Chermes lariciatus*. Pupa developing in spruce gall.
- Fig. 123. *Chermes consolidatus* Patch. Migrant which develops in spruce gall. Figs. 124, 124a. Antenna. Notice two strong terminal spines.

- Fig. 125. *Chermes consolidatus*, pupa developing in spruce gall.
- Fig. 126. *Chermes consolidatus*? Apterous oviparous form on larch.
- Fig. 127. *Chermes pinifoliae* Fitch. Migrants from spruce to white pine needles.
- Fig. 128. *Chermes pinifoliae*. Mature galls from black spruce still green and just before opening.
- Fig. 129. Branch of black spruce. *A* cone with tip broken, *B* four normal spruce tips, *C* four young galls of *pinifoliae*.
- Fig. 130. Tip of black spruce. *A* cone which is purple, *B* normal tip, *C* deserted *pinifoliae* gall which is bright reddish brown.
- Fig. 131. Deserted galls of *Chermes pinifoliae* on red spruce.
- Fig. 132. White pine showing injury to new growth by the young *pinifoliae* which may be located by the white secretion on twig at base of new growth. Photographed July 23, 1909.
- Fig. 133. *Chermes floccus* Patch, migrants from spruce galls, ovipositing on white pine needles.
- Fig. 134. Galls of *Chermes floccus* on red spruce. The white objects on the outside of the gall are waxy secretions of *Chermes similis*, apterous forms, which are ovipositing on *floccus* galls as well as on the twig.
- Fig. 135. Gall of *Chermes floccus* from black spruce. Cross section.
- Fig. 136. Longitudinal section.
- Fig. 137. Twig of white spruce with galls of *Chermes abietis*.
- Fig. 138. Galls of *Chermes abietis* from Norway spruce. Longitudinal section of gall which does not enclose the whole twig. Fig. 139. Longitudinal section of gall which completely encircles the twig.
- Fig. 140. Twig of Norway spruce. Show deserted gall of *Chermes abietis* and the white molted skins along twig and leaves.
- Fig. 141. Twig of white spruce with galls of *Chermes lariciatus* Patch. Gall at right deserted. Gall at left not yet opened.
- Fig. 142. Galls of *Chermes similis* Gillette on Norway spruce.
- Fig. 143. Apterous flocculent oviparous females of *Chermes similis* showing white on stem of Norway spruce.
- Fig. 144. Twig of black spruce showing injury to young of *Chermes similis*. Needles sickly yellow, and covered with white flocculent secretion of the *Chermes*.
- Fig. 145. Gall of *Chermes consolidatus* Patch on black spruce.
- Fig. 146. *Chermes pinicorticis* Fitch on bark of white pine.

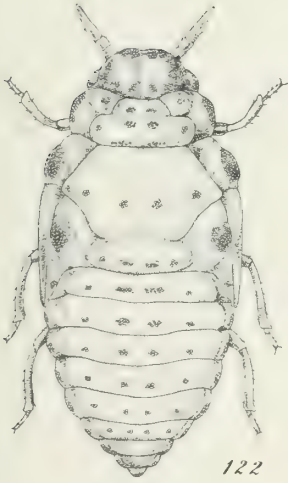
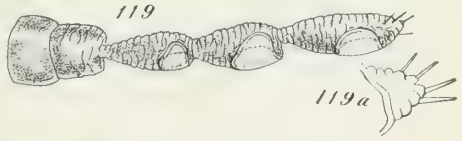
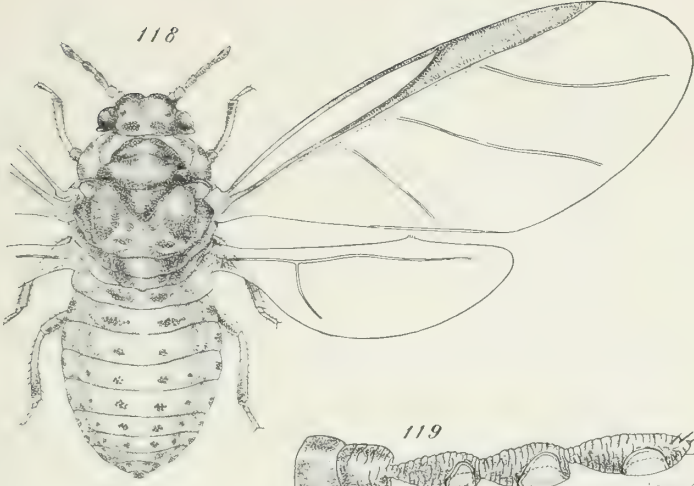


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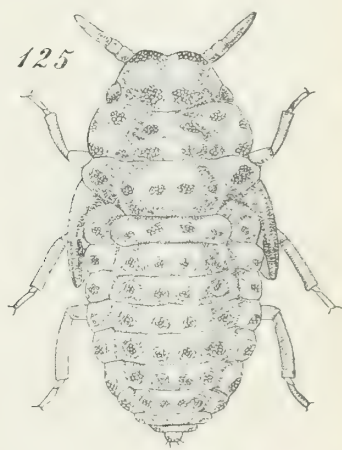
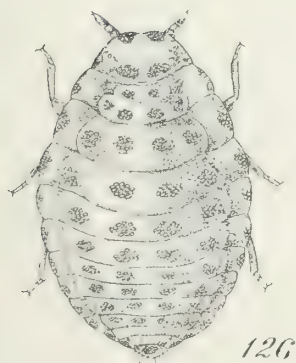
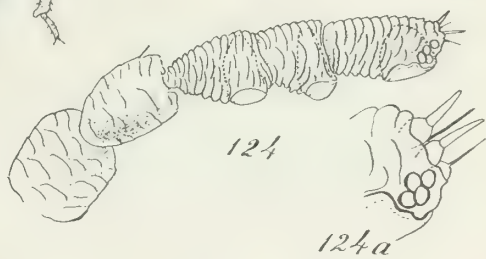
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Fig. 127



Fig. 128

Chermes pinifoliae Fitch. Fig. 127, Migrants on white pine. Fig. 128, Galls on black spruce.

Fig. 129



Fig. 131



Fig. 130

Chermes pinifoliae Fitch. Galls on spruce.





Fig. 132

Chermes binifoliae Fitch. Young in white secretion towards tips of twigs of white pine



Fig. 133



Fig. 135

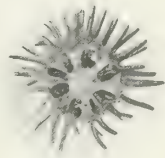


Fig. 134

Fig. 136

Chermes floccus Patch. Migrants on white pine and galls on spruce





Fig. 137. *Chermes abietis* Linn. Galls on white spruce



Fig. 138



Fig. 139



Fig. 140

Chermes abietis Linn. Galls on Norway spruce





Fig. 141. *Chermes lariciatus* Patch. Galls on white spruce





Fig. 142. *Chermes similis* Gillette. Galls on Norway spruce

Fig. 143



Fig. 144

Chermes similis Gillette

Fig. 145

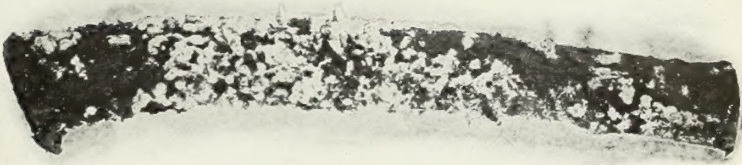


Fig 146

Fig. 145. *Chermes consolidatus* Patch. Gall on black spruce
Fig. 146. *Chermes pinicorticis* Fitch. On bark of white pine.

